Status of the dE/dx cosmic rays measurements with PANDA straw tubes prototype in Julich.

Valery Serdyuk, FZJ Julich, JINR Dubna

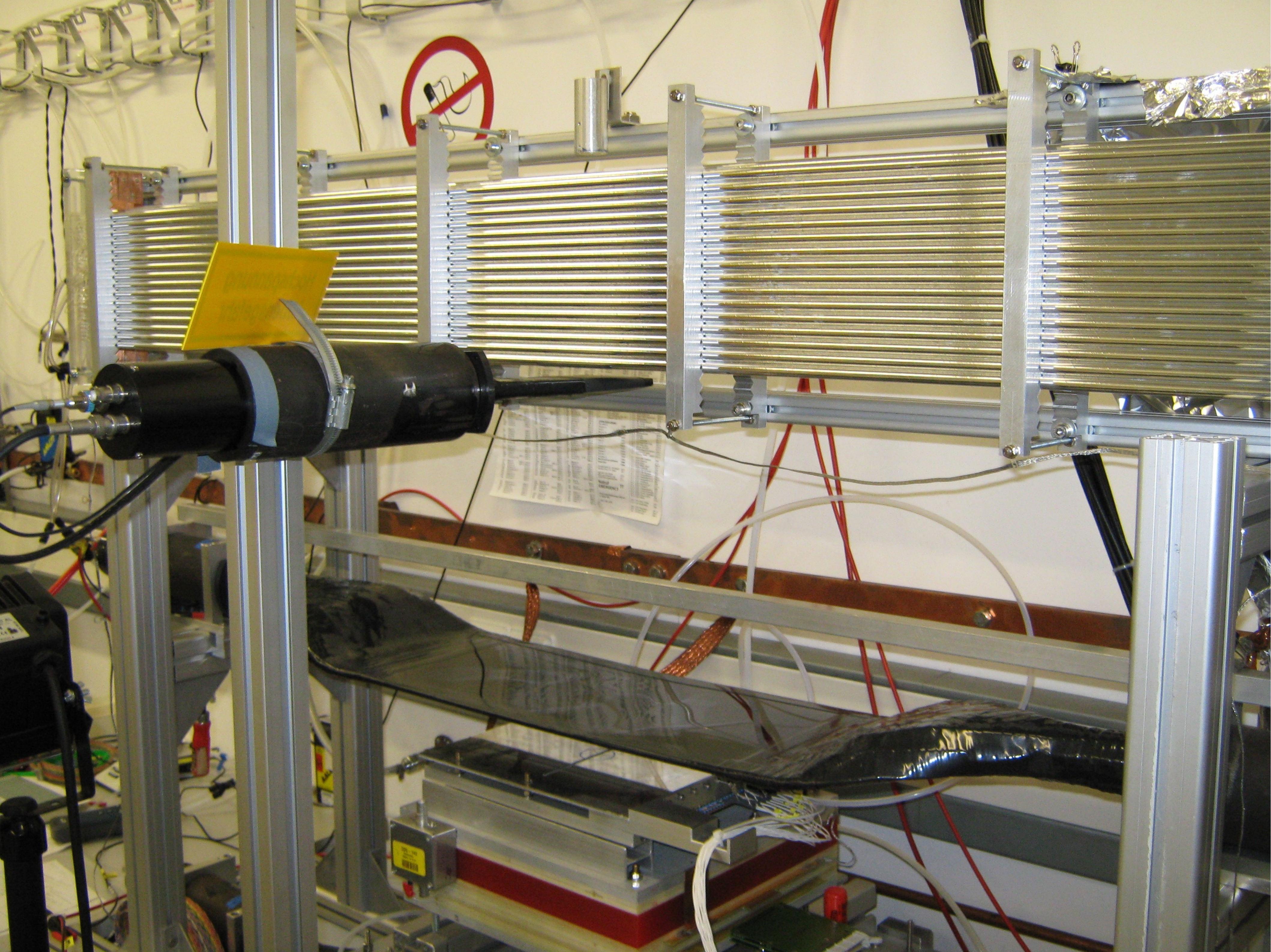
Goal: investigations of tracking and particle identification by multiple ionizations measurements;

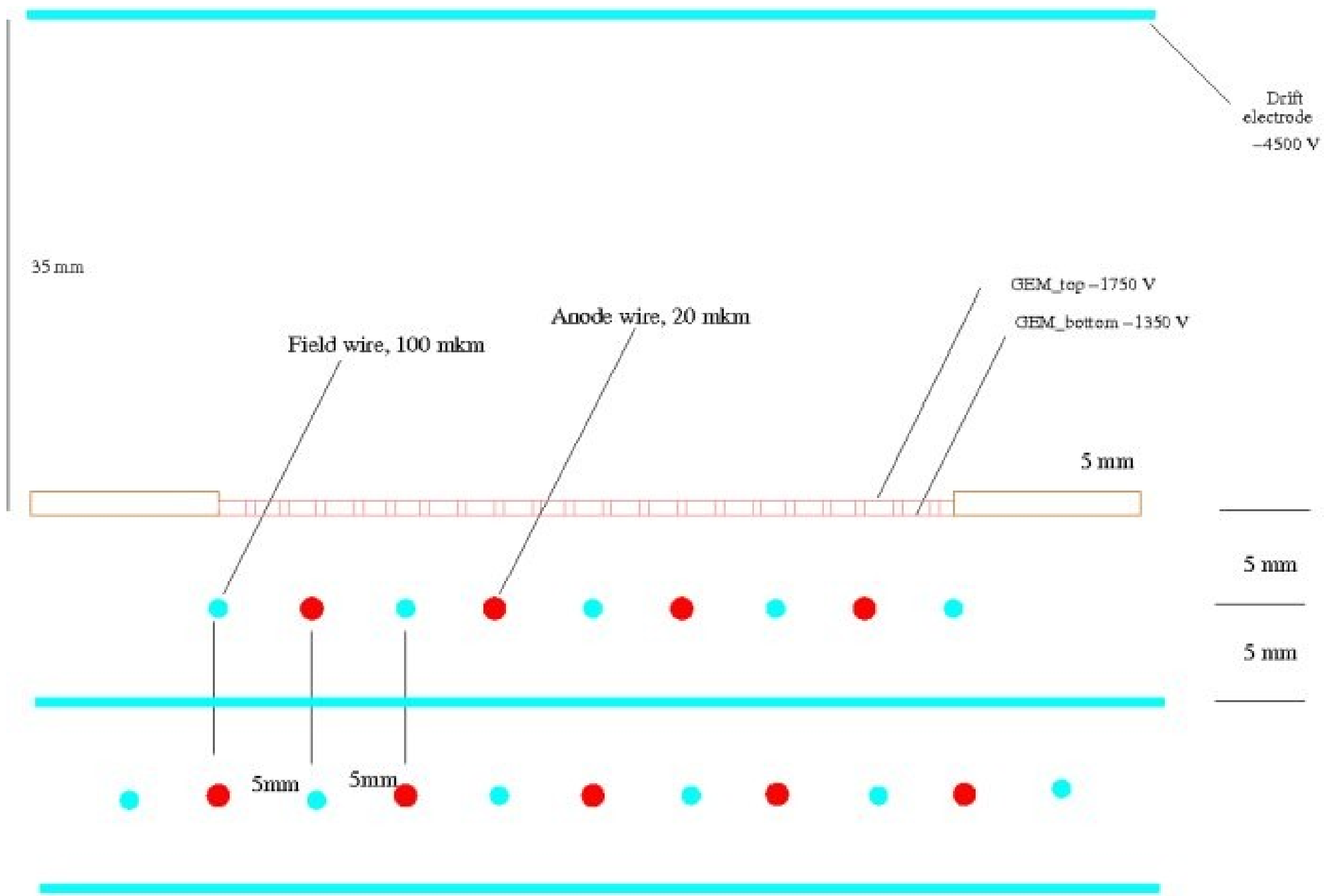
assembling of a straw detector prototype for test in laboratory with cosmic rays and radioactive sources,

150 cm long straw tubes, 10 mm diameter, double side aluminum mylar, 8 layers of 16 straws

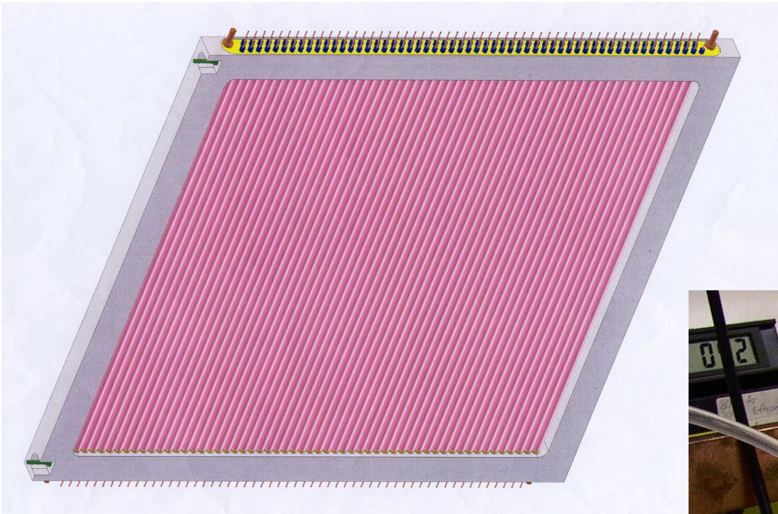
Integration of this prototype in an existing laboratory setup with tracking detectors, test electronics and data acquisition

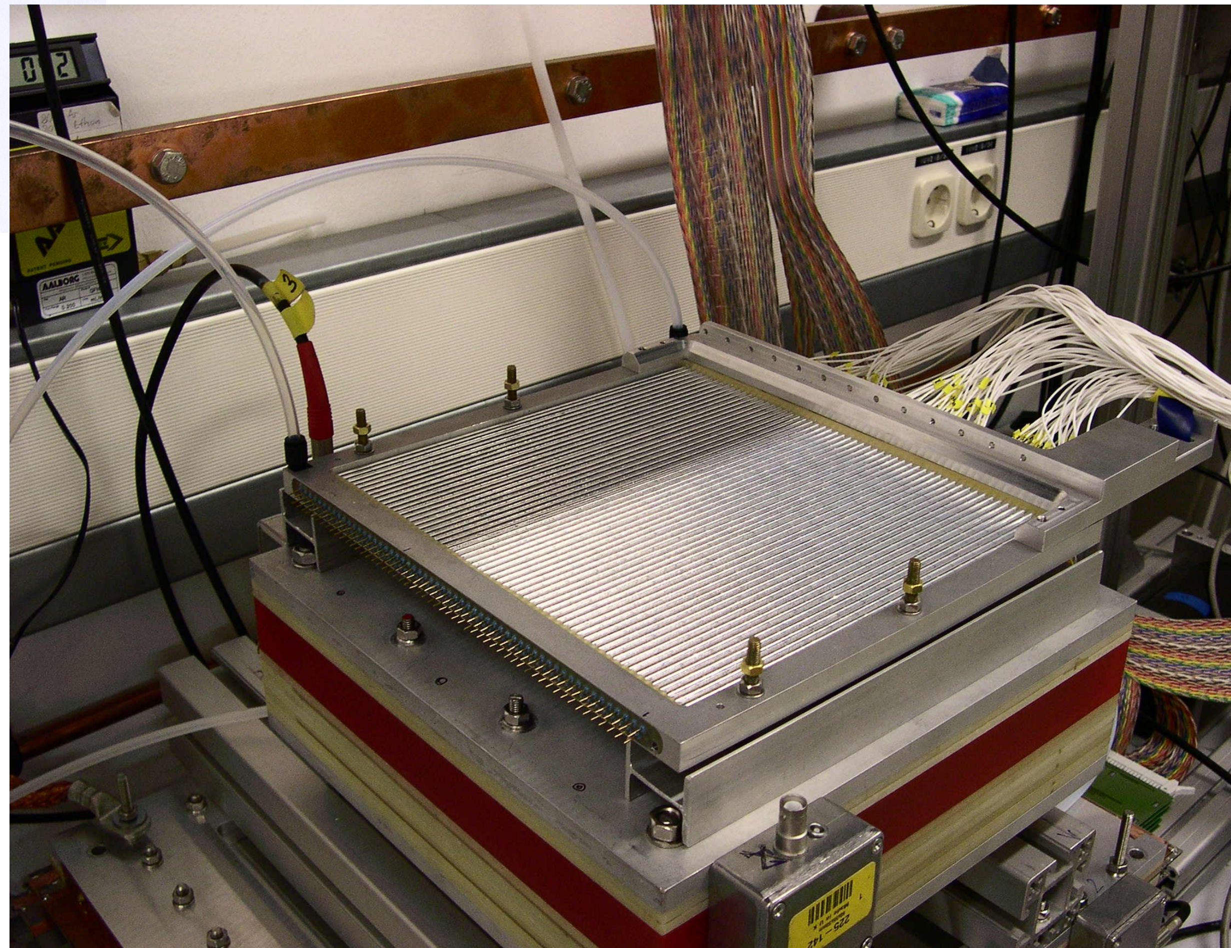
Testing DAQ, readout, analysis software - ROOT Sorter, ROOT





Drift electrode
–4500 V
35 mm
GEM_top –1750 V
GEM_bottom –1350 V
Anode wire, 20 mkm
Field wire, 100 mkm
5 mm
5 mm
5 mm
5mm
5mm





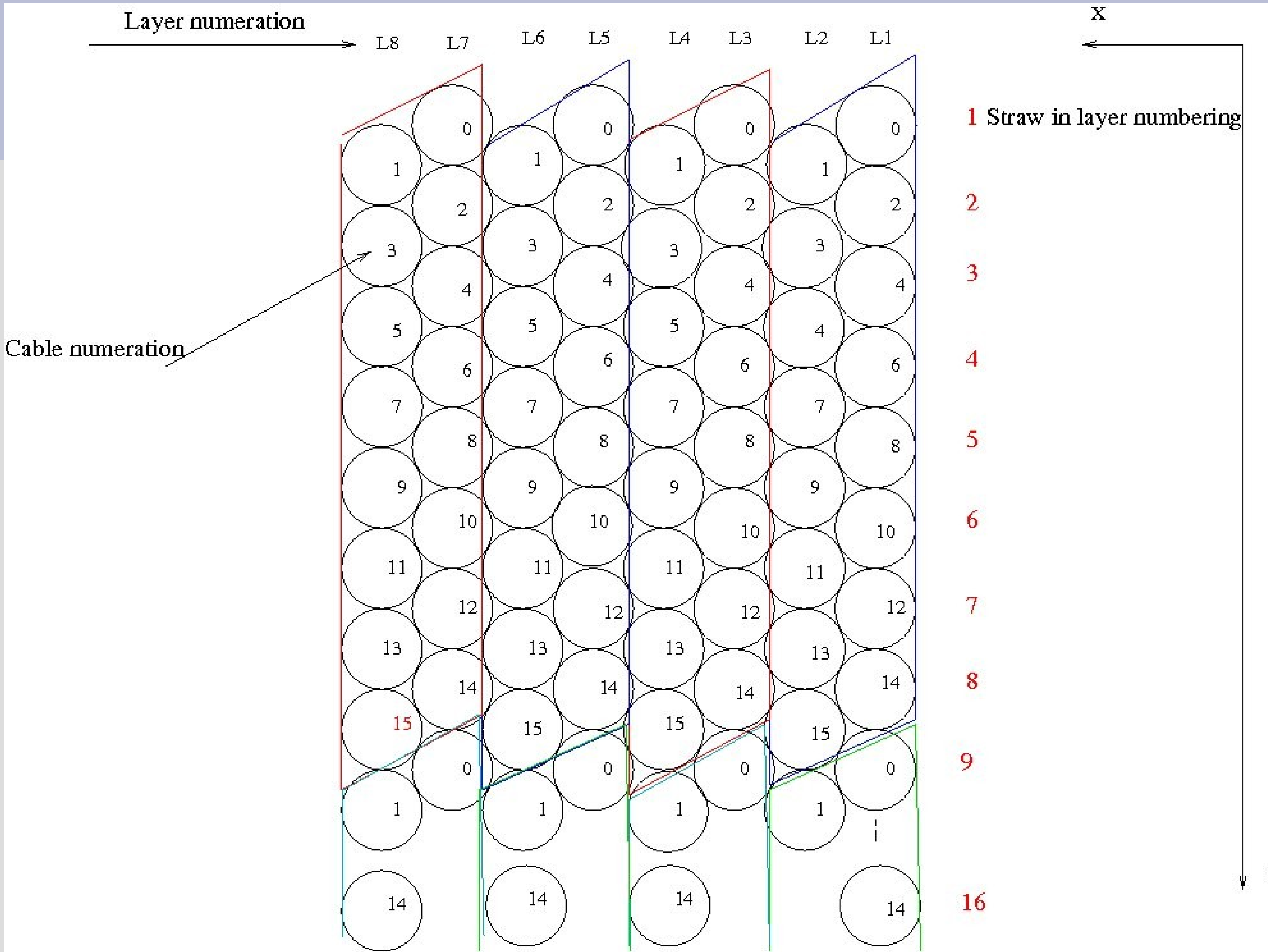
Detectors:

- straw tube detector:

straws 4 mm diameter, 2 layers, S=4.4 mm, dZ=4 mm,
111 straws, sensitive area ~ 23-24 cm^2

6 plane module drift chamber:
2*X, 2*+30deg, 2*-30 deg, 10 mm drift cell (+- 5 mm)

a hybrid detector – with GEM foil - gas electron multiplier, inserted in a drift chamber as a preamplifier for registration of ionization clusters



Layer numeration
L8
L7
L6
L5
L4
L3
L2
L1
x
z
1 Straw in layer numbering
2
3
4
5
6
7
8
9
16
Cable numeration

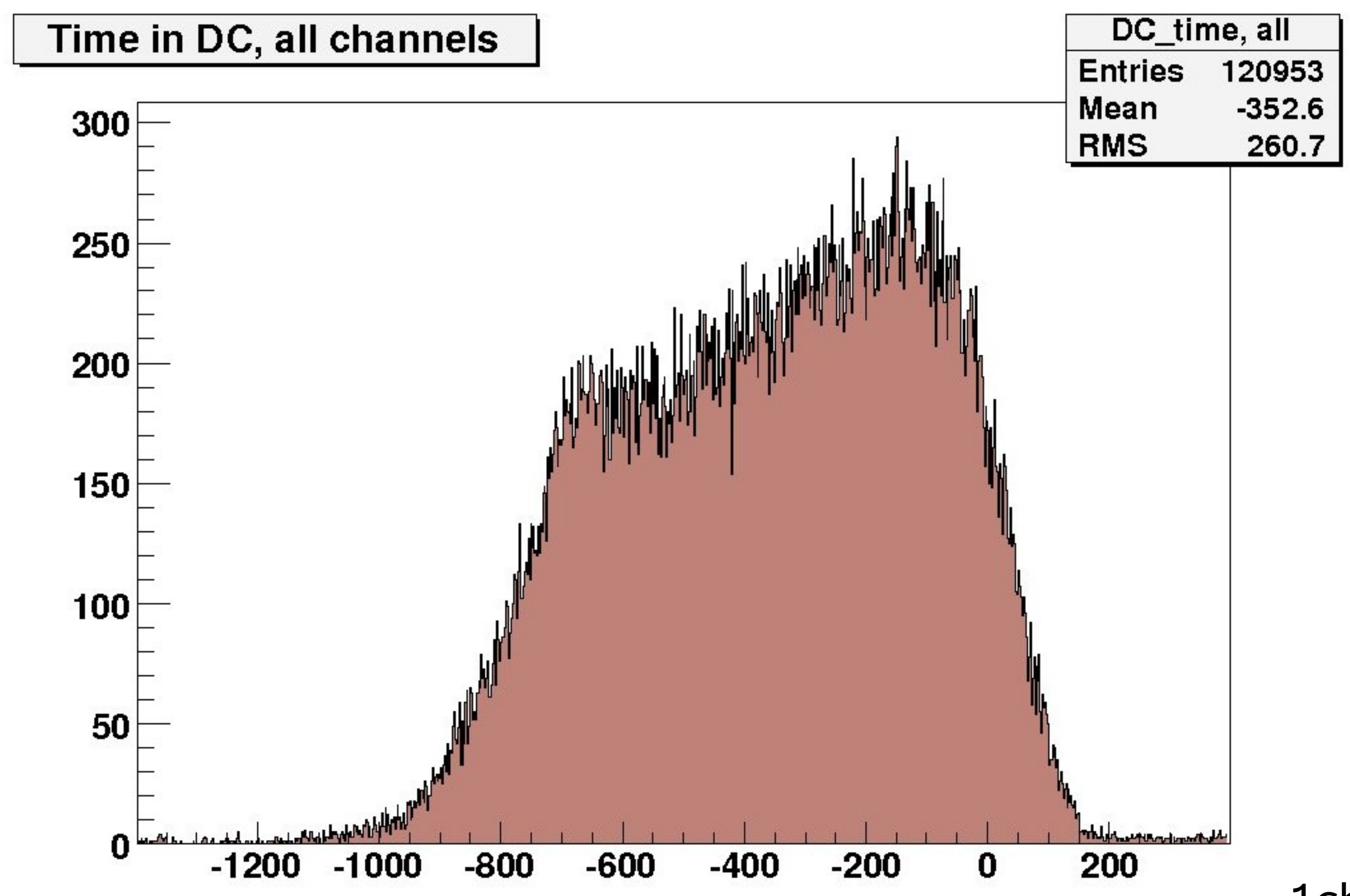
Electronics used in measurements

- a 16 channels current amplifier (CMD components), gain 10 mV/μa, rise time < 8 ns, noise ~ 1 μa; bypolar output
- amplifier-discriminator CMP 16, amplification 8 mV/fC rise time 7 ns, LVDS output
- adapters and booster amplifiers for creating unipolar signals and matching between analog and digital electronics
-

TDC-F1, 64 channels, LVDS input, in normal resolution mode 7.8 μs measurement range, resolution 130 ps LSB, used in WASA and ANKE at COSY

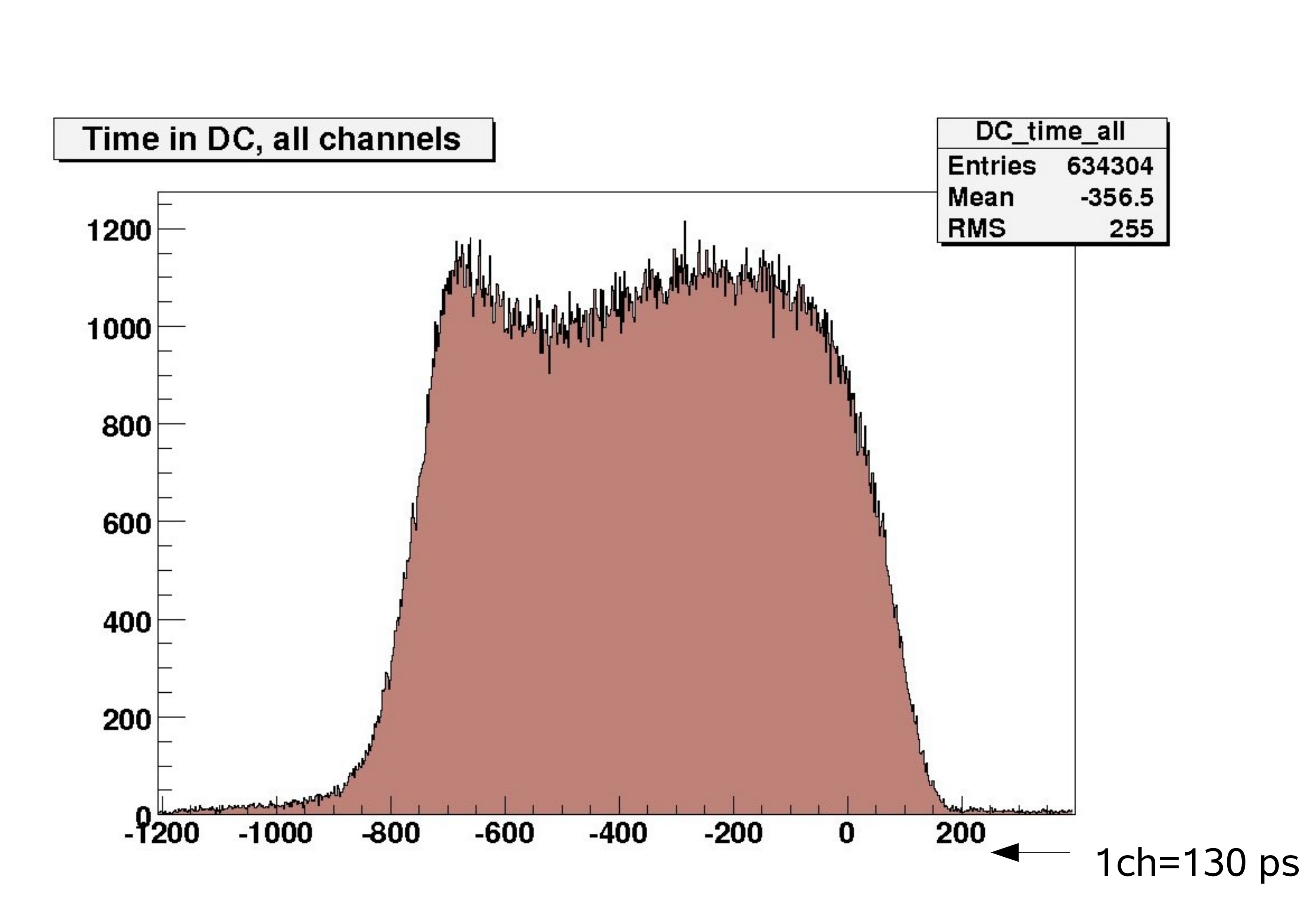
Fast QDC – a flash ADC with a sampling frequency of 160 MHz, range 6.4 μks, 11 bits, up to 0.4 V.
FPGA programmed algorithm which gives: the number of pulses, time position (~1.56 ns), amplitudes, charges, used in WASA at COSY

run3393, Ar/C2H6 80/20, 1.7 kV, dP=974 mbar

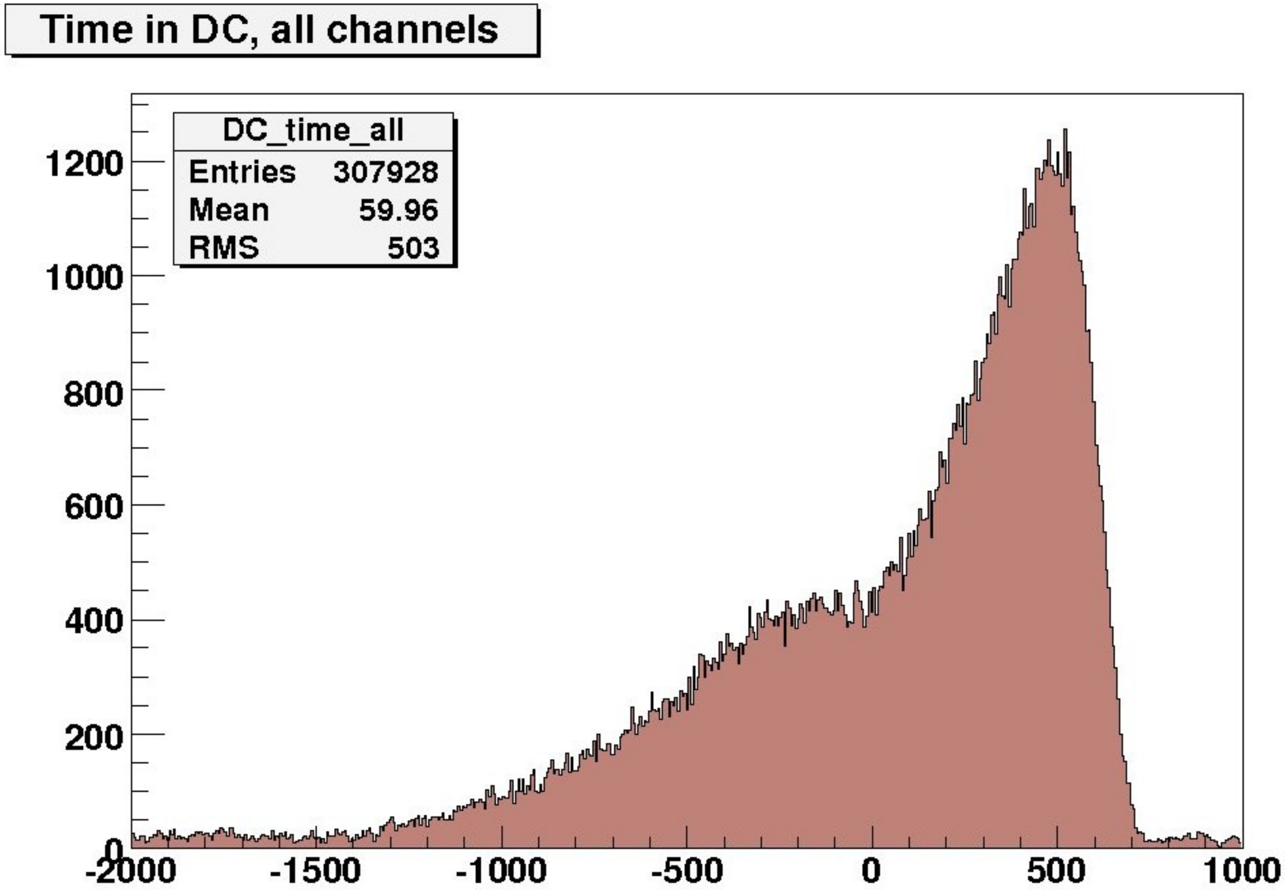


1ch=130 ps

run 3406, cosmics, Ar/C2H6 (80/20), 1.6 kV, dP=449 mbar

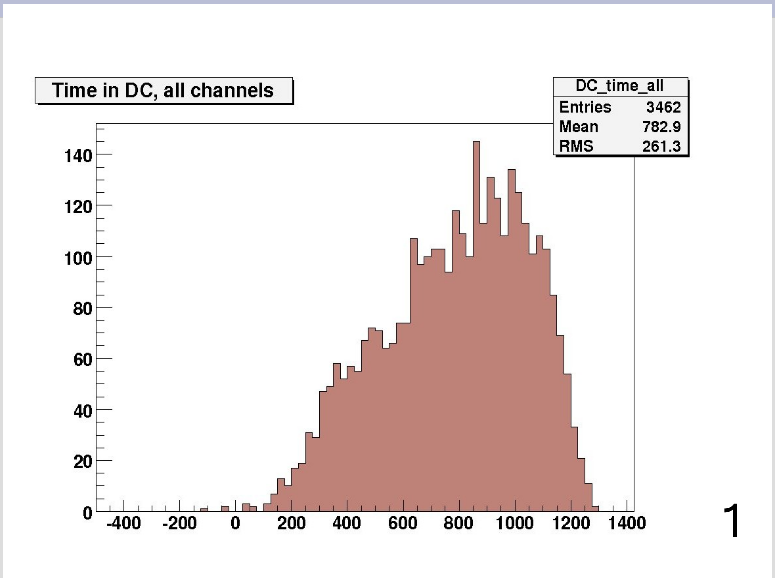


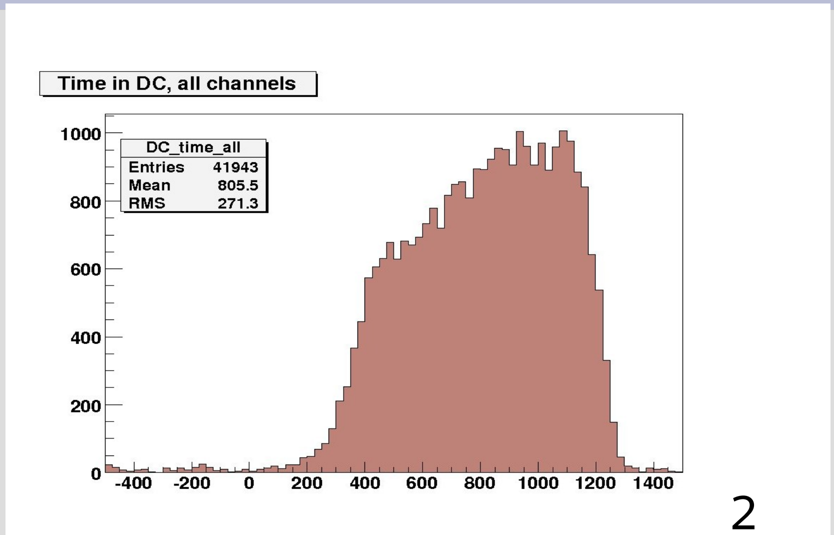
run3437, cosmics, Ar/CO2 (90/10), 1.7 kV, dP=1020 mbar

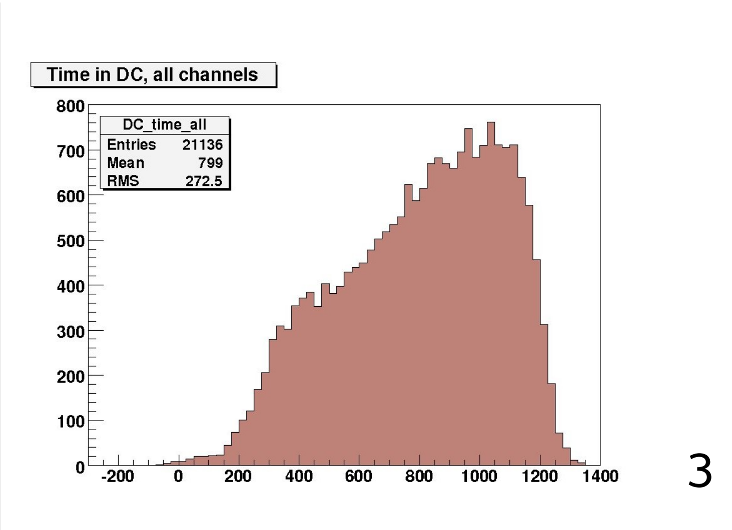


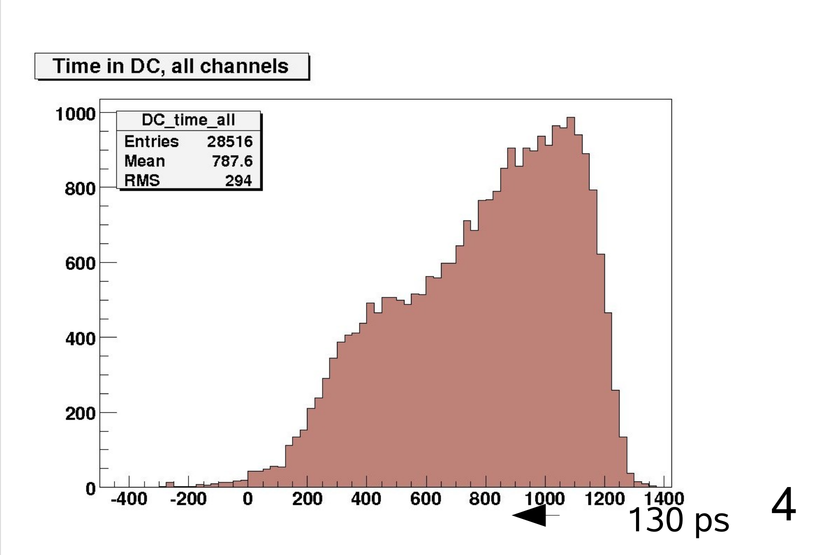
1ch=130 ps

1 - 1.45 kV, dP=290 mbar; 2 – 1.6 kV, dP=290 mbar; 3 – 1.6 kV, dP=452 mbar; 4 – 1.6 kV, dP=651 mbar Ar/CO2 90/10

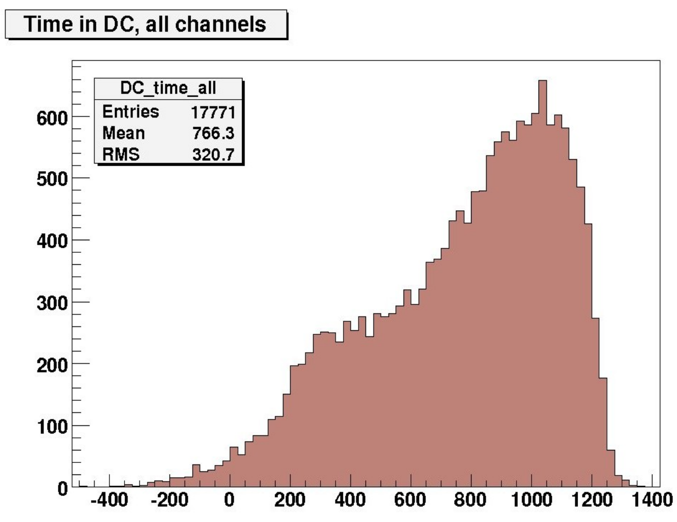




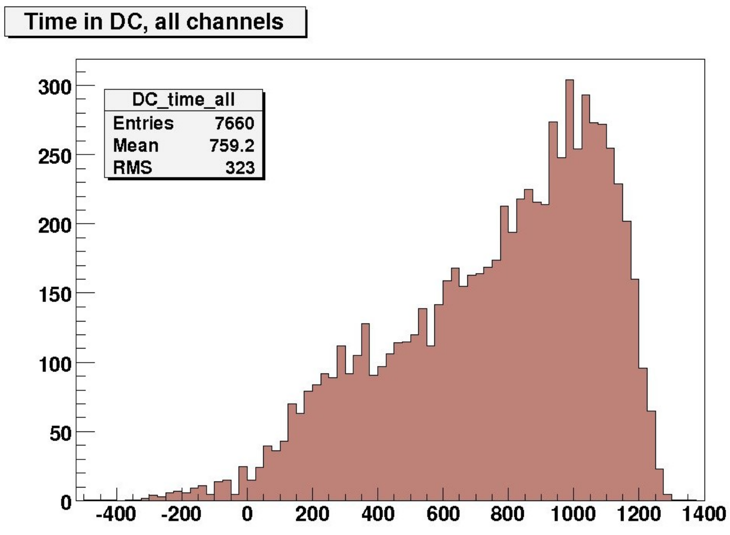




1 – 1.7 kV, dP=803 mbar; 2 – 1.7 kV, dp=901 mbar; 3 – 1.7 kV, dP=991 mbar; 4 – 1.8 kV, dP=991 mbar; Ar/CO2 90/10



1



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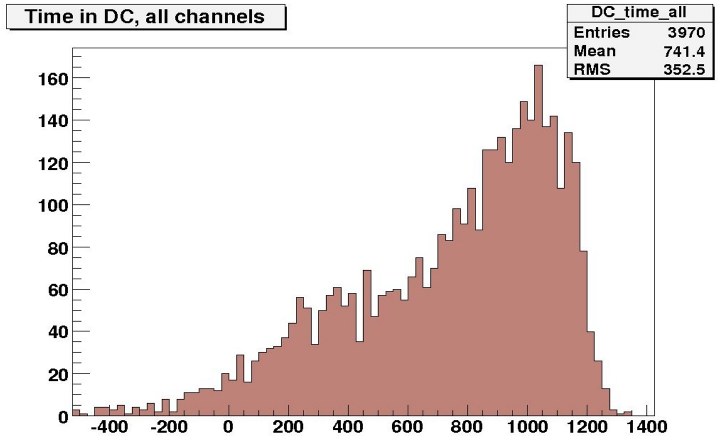

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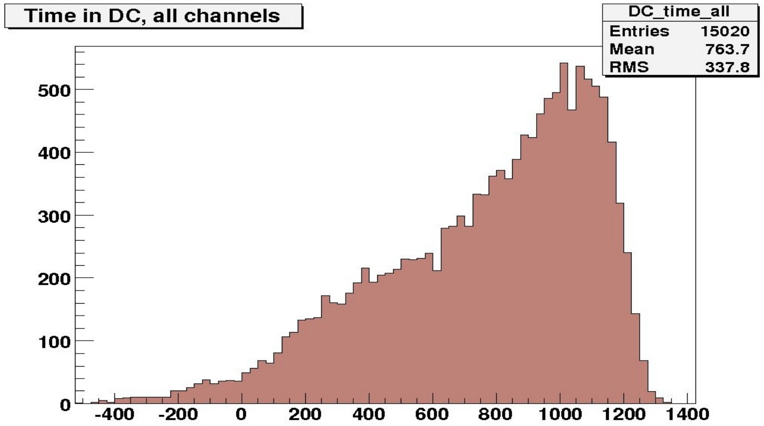
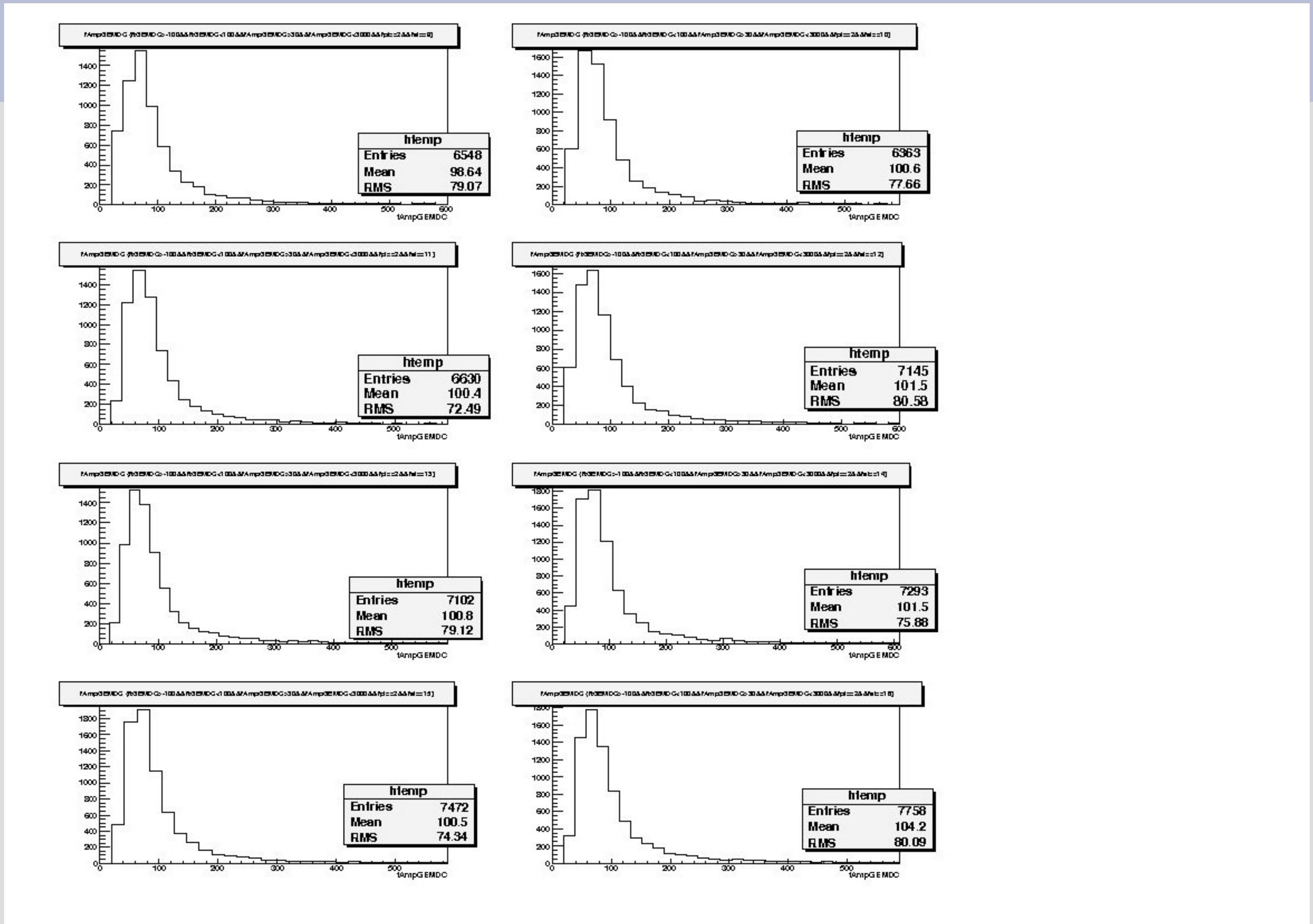
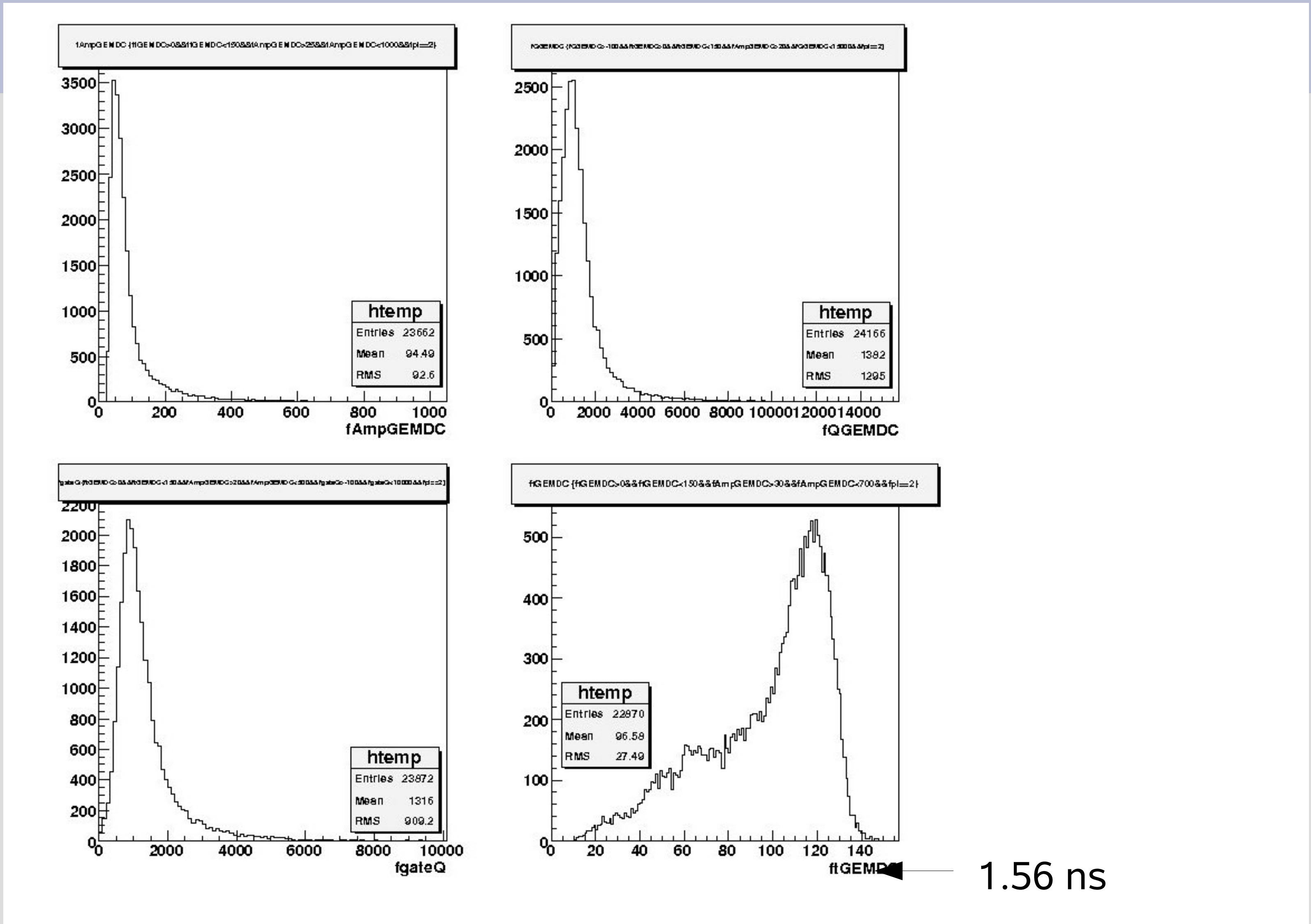


4

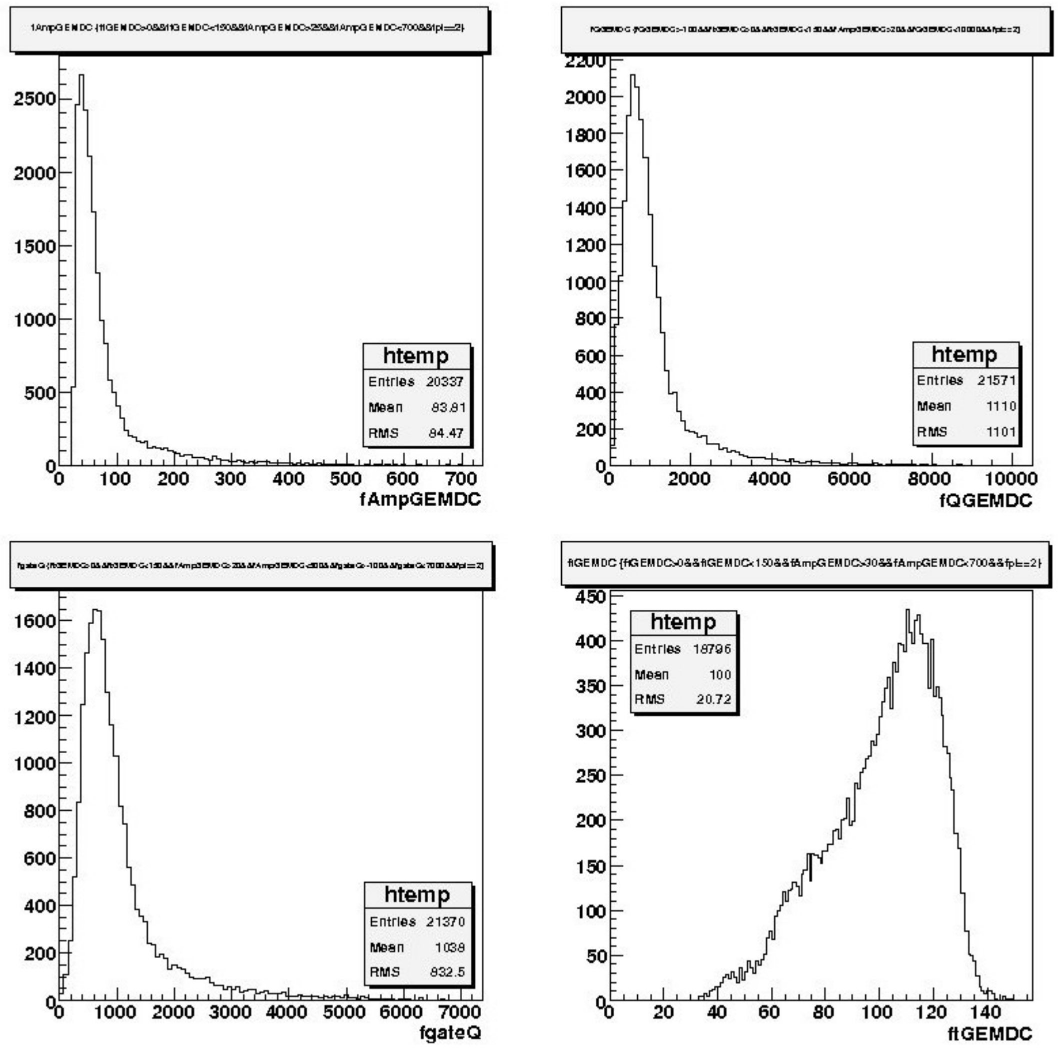
Amplitude spectra, FQDC, 8 channels, run3391, Ar/C2H6 (80/20),1.7 kV,dP=986mbar

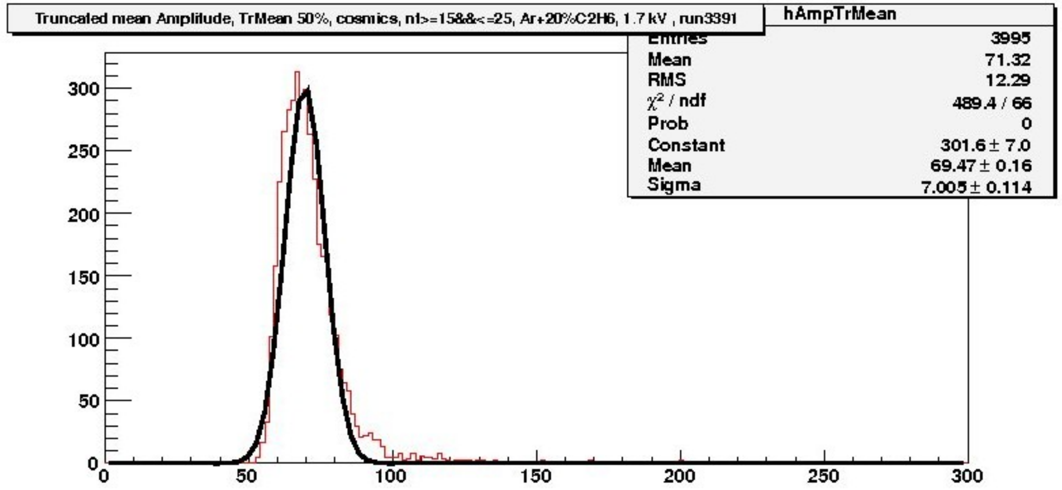


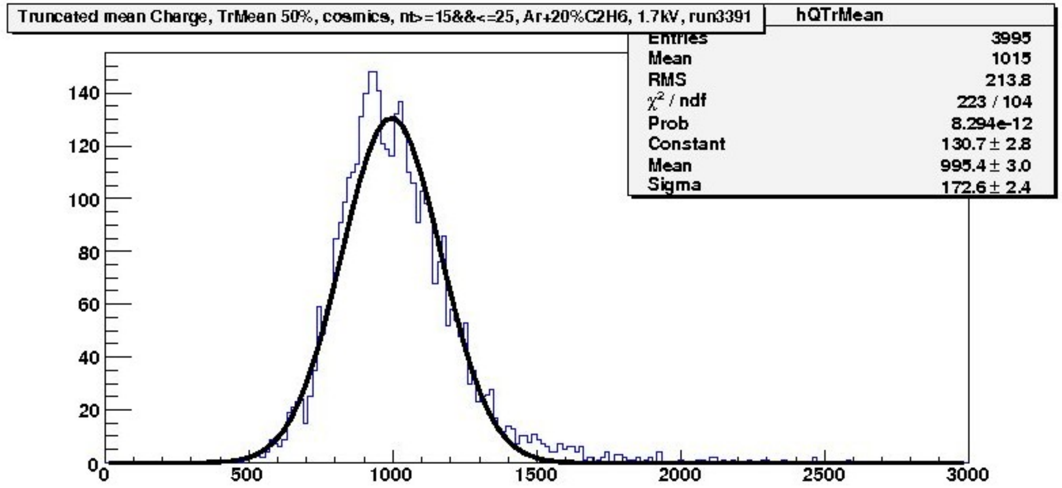
run 3500, Sr90, 1.7 kV, dP=991 mbar, Ar/CO2 90/10

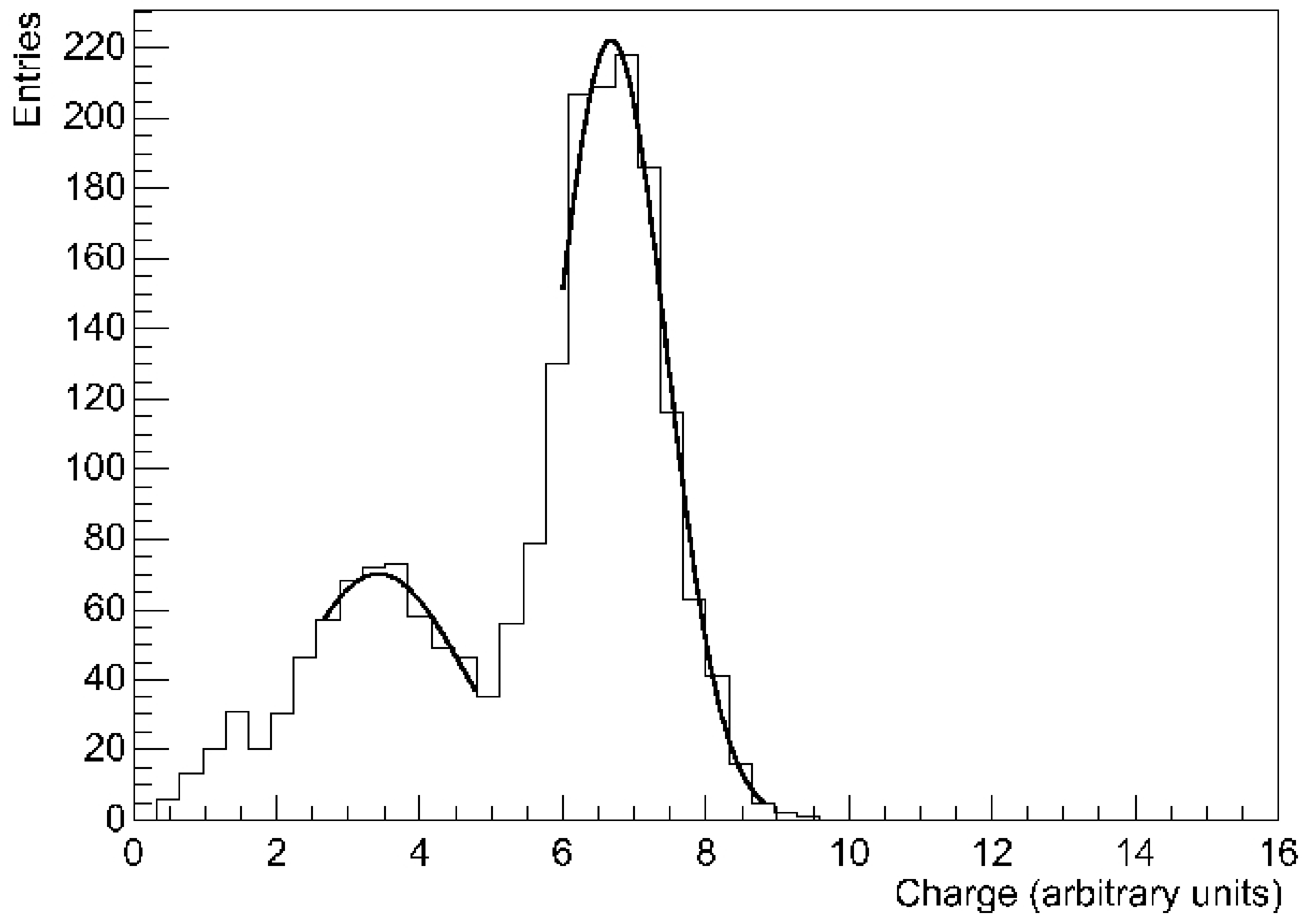


run3515, 1.45 kV, dP=290 mbar, Ar/CO2, 90/10

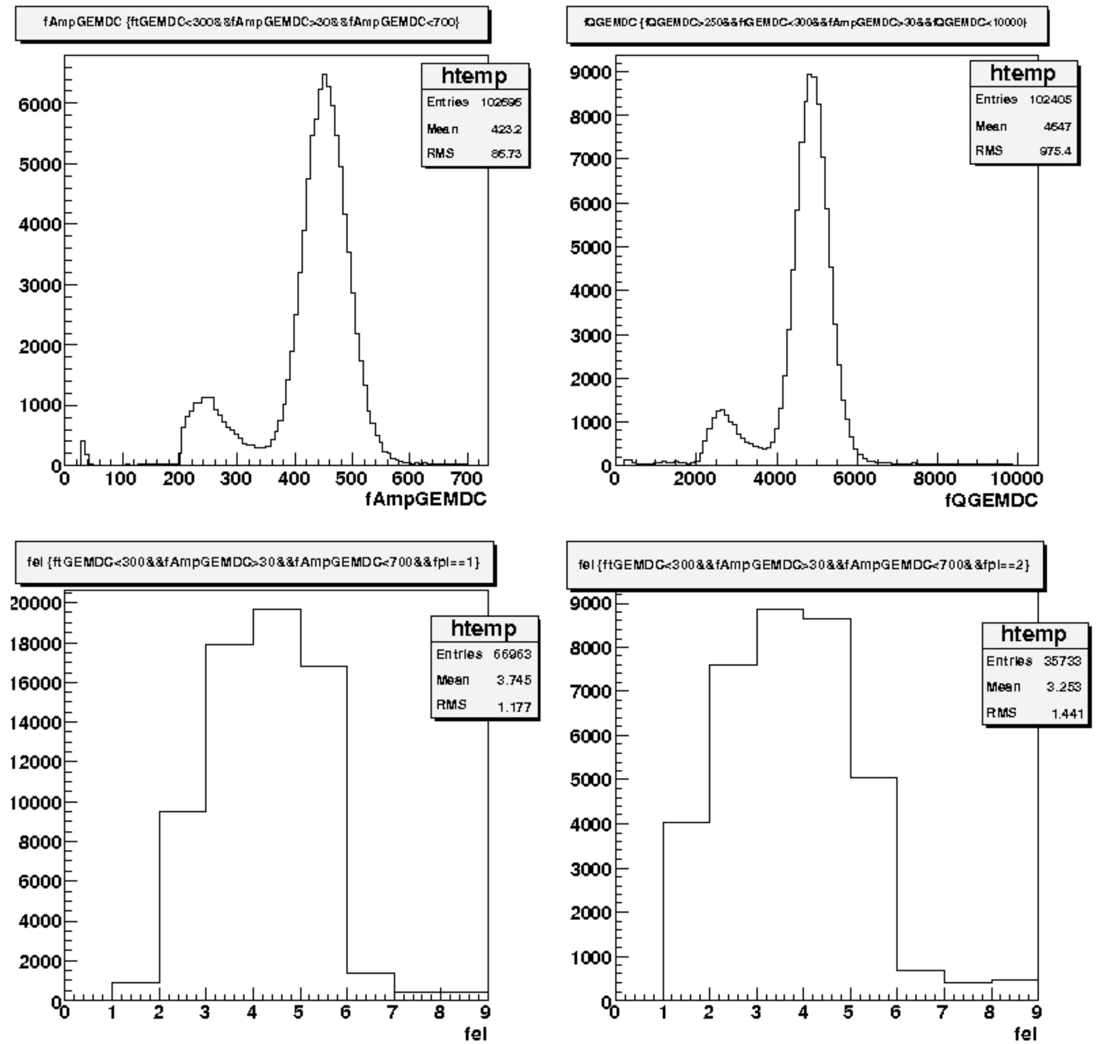


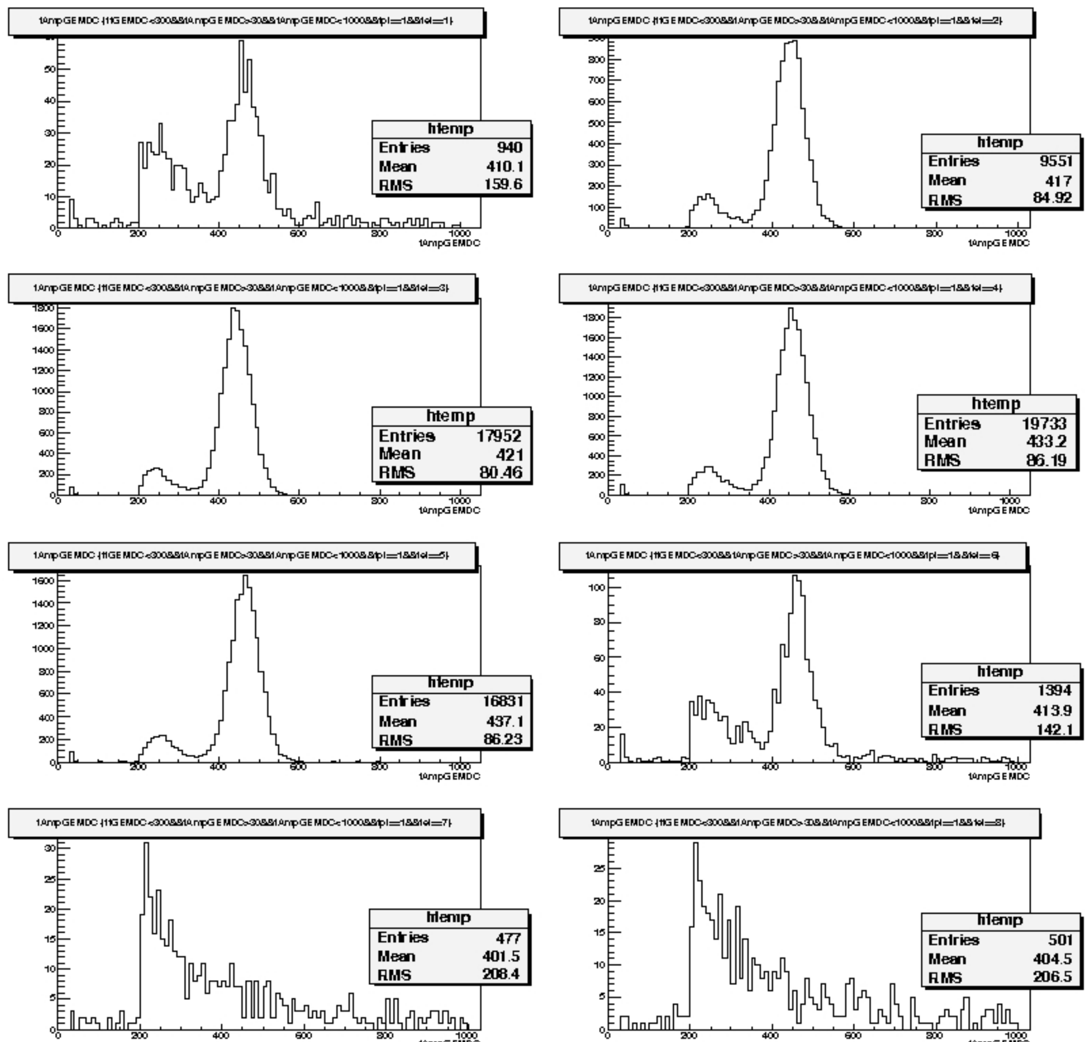

Truncated mean Amplitude, TrMean 50%, cosmics, nt>=15&&<=25, Ar+20%C2H6, 1.7 kV , run3391
hAmpTrMean
Entries 3995
Mean 71.32
RMS 12.29
χ2 / ndf 489.4 / 66
Prob 0
Constant 301.6 ± 7.0
Mean 69.47 ± 0.16
Sigma 7.005 ± 0.114

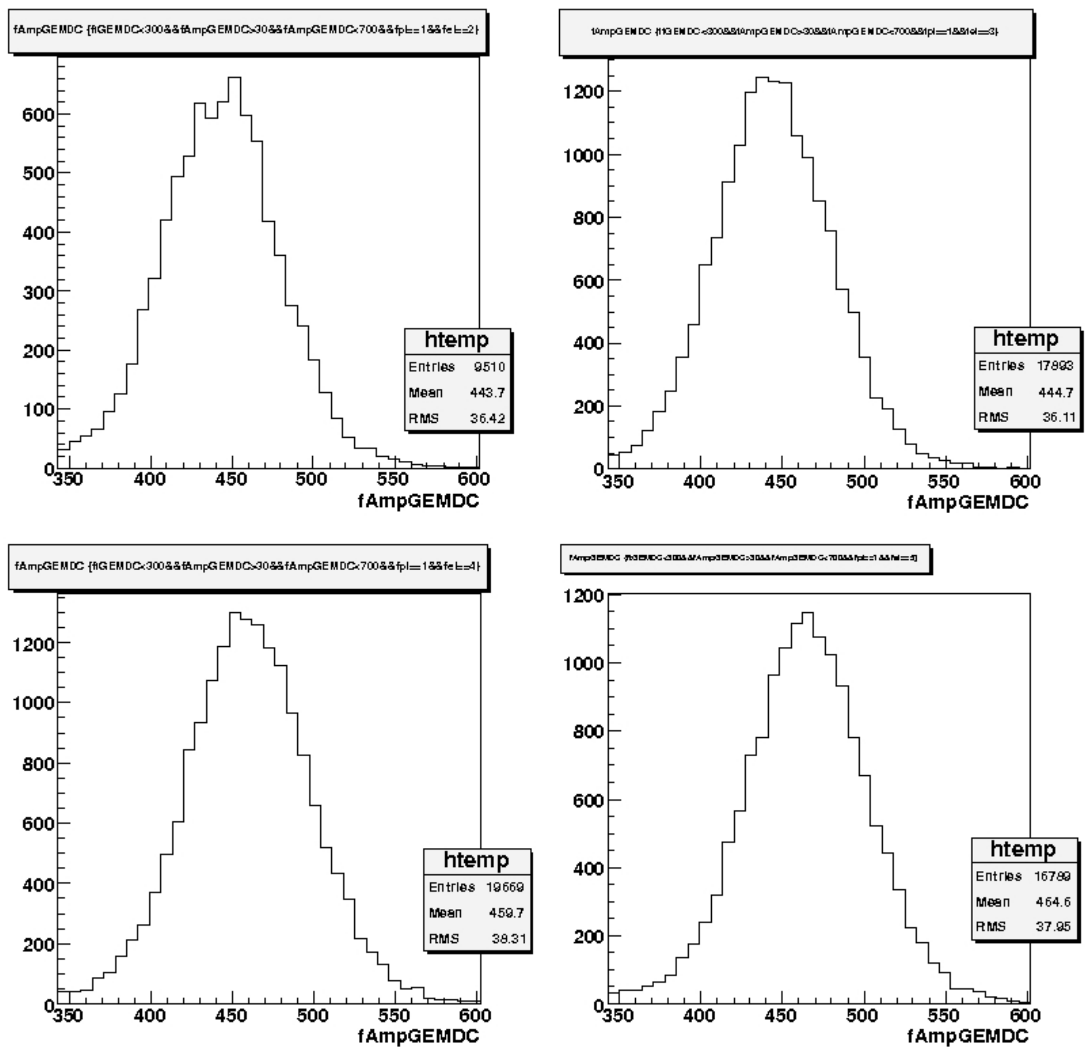

Truncated mean Charge, TrMean 50%, cosmics, nt>=15&&<=25, Ar+20%C2H6, 1.7kV, run3391
hQTrMean
Entries 3995
Mean 1015
RMS 213.8
χ2 / ndf 223 / 104
Prob 8.294e-12
Constant 130.7 ± 2.8
Mean 995.4 ± 3.0
Sigma 172.6 ± 2.4

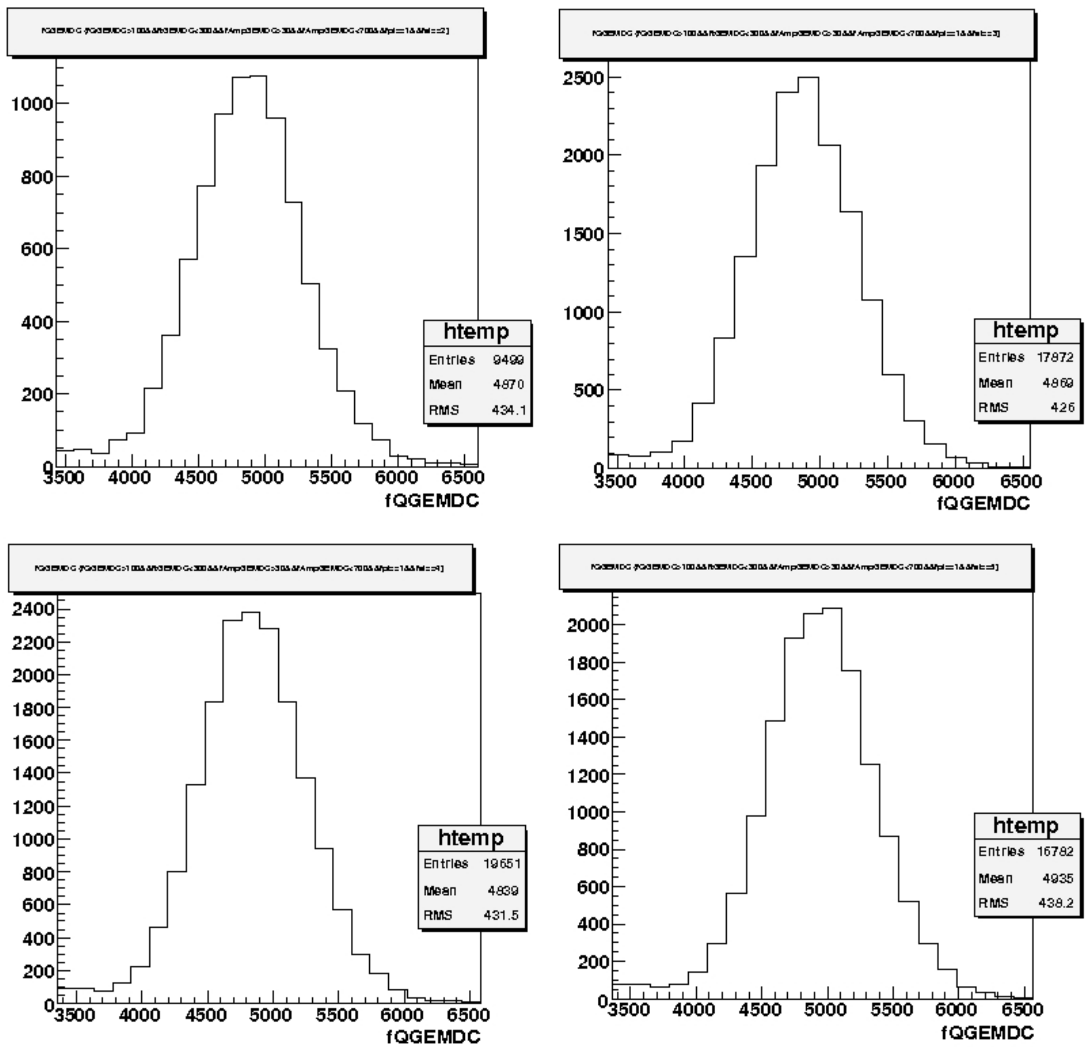

Entries
220
200
180
160
140
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
16
Charge (arbitrary units)

Fe55, Ar/CO2, dP=282 mbar, 1.5 kV




tAmpGEMDC {tTGEMDC<300&&tAmpGEMDC>30&&tAmpGEMDC<1000&&tpl==1&&tel==1}
htemp
Entries 940
Mean 410.1
RMS 159.6
tAmpGEMDC {tTGEMDC<300&&tAmpGEMDC>30&&tAmpGEMDC<1000&&tpl==1&&tel==2}
htemp
Entries 9551
Mean 417
RMS 84.92
tAmpGEMDC {tTGEMDC<300&&tAmpGEMDC>30&&tAmpGEMDC<1000&&tpl==1&&tel==3}
htemp
Entries 17952
Mean 421
RMS 80.46
tAmpGEMDC {tTGEMDC<300&&tAmpGEMDC>30&&tAmpGEMDC<1000&&tpl==1&&tel==4}
htemp
Entries 19733
Mean 433.2
RMS 86.19
tAmpGEMDC {tTGEMDC<300&&tAmpGEMDC>30&&tAmpGEMDC<1000&&tpl==1&&tel==5}
htemp
Entries 16831
Mean 437.1
RMS 86.23
tAmpGEMDC {tTGEMDC<300&&tAmpGEMDC>30&&tAmpGEMDC<1000&&tpl==1&&tel==6}
htemp
Entries 1394
Mean 413.9
RMS 142.1
tAmpGEMDC {tTGEMDC<300&&tAmpGEMDC>30&&tAmpGEMDC<1000&&tpl==1&&tel==7}
htemp
Entries 477
Mean 401.5
RMS 208.4
tAmpGEMDC {tTGEMDC<300&&tAmpGEMDC>30&&tAmpGEMDC<1000&&tpl==1&&tel==8}
htemp
Entries 501
Mean 404.5
RMS 206.5
tAmpGEMDC


fAmpGEMDC {ftGEMDC<300&&fAmpGEMDC>30&&fAmpGEMDC<700&&fpl==1&&fel==2}
htemp
Entries 9510
Mean 443.7
RMS 36.42
fAmpGEMDC
fAmpGEMDC {ftGEMDC<300&&fAmpGEMDC>30&&fAmpGEMDC<700&&fpl==1&&fel==3}
htemp
Entries 17893
Mean 444.7
RMS 36.11
fAmpGEMDC
fAmpGEMDC {ftGEMDC<300&&fAmpGEMDC>30&&fAmpGEMDC<700&&fpl==1&&fel==4}
htemp
Entries 19669
Mean 459.7
RMS 38.31
fAmpGEMDC
htemp
Entries 16789
Mean 464.6
RMS 37.95
fAmpGEMDC



htemp
Entries 9499
Mean 4870
RMS 434.1
fQGEMDC
htemp
Entries 17872
Mean 4869
RMS 426
fQGEMDC
htemp
Entries 19651
Mean 4839
RMS 431.5
fQGEMDC
htemp
Entries 16782
Mean 4935
RMS 438.2
fQGEMDC

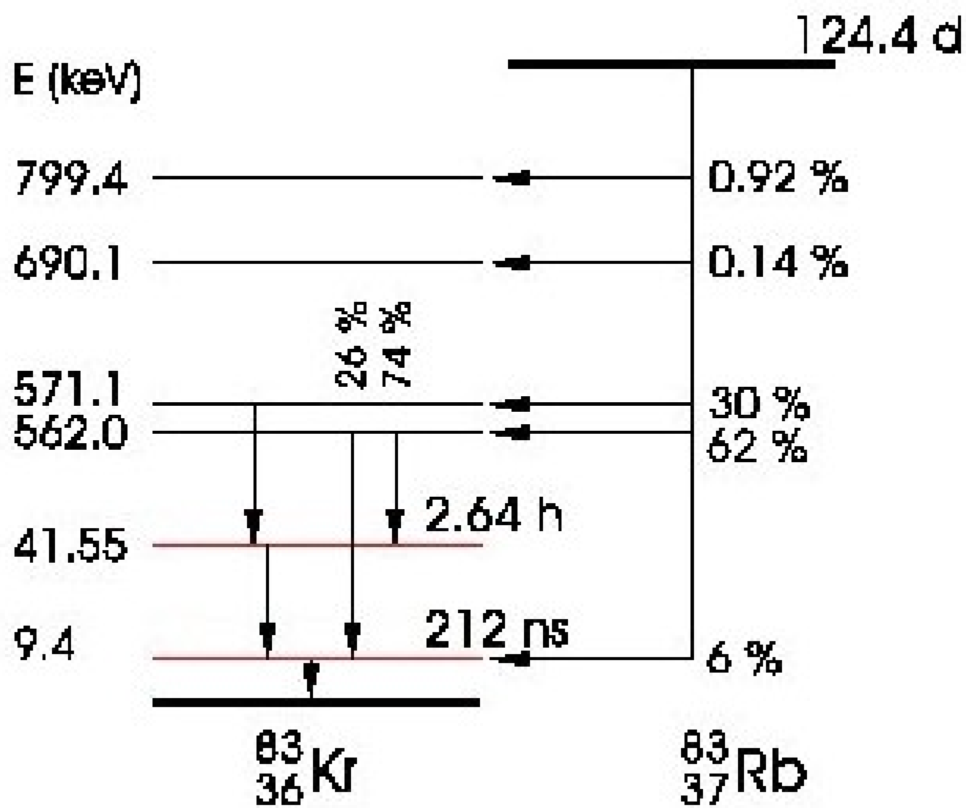
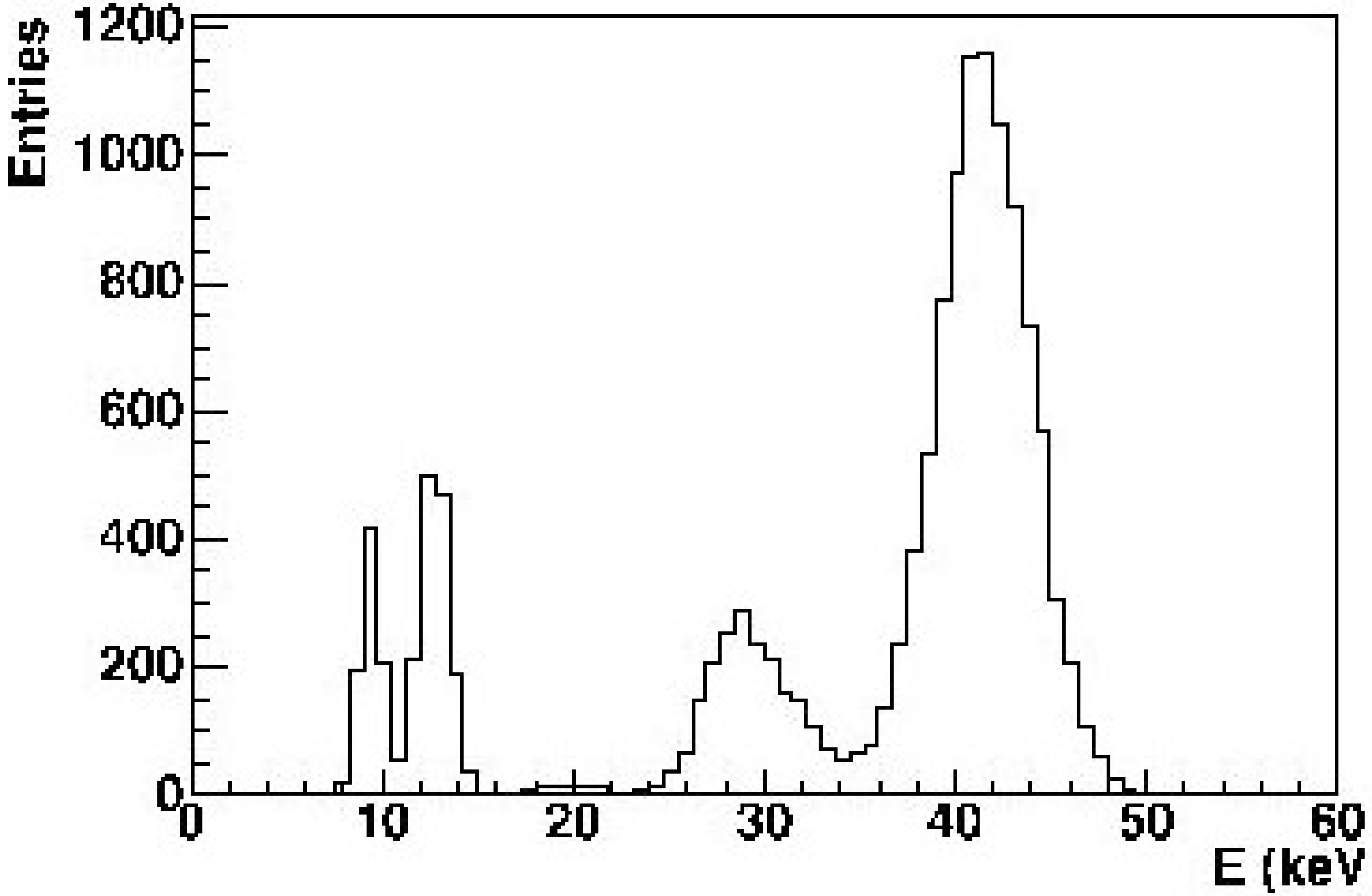


Fig. 2. Decay scheme of ^{83}Rb — ^{83}Kr. The ground state of ^{83}Rb decays predominantly (76 %) to the isomeric excited state ^{83m}Kr at $E = 41.6$ keV. This most important level of ^{83}Kr for calibration is populated through the 571 keV and 562 keV intermediate levels. It decays entirely to the 9.4 keV state, which then decays to the ^{83}Kr ground state.


Entries
1200
1000
800
600
400
200
0
0
10
20
30
40
50
60
E (keV)

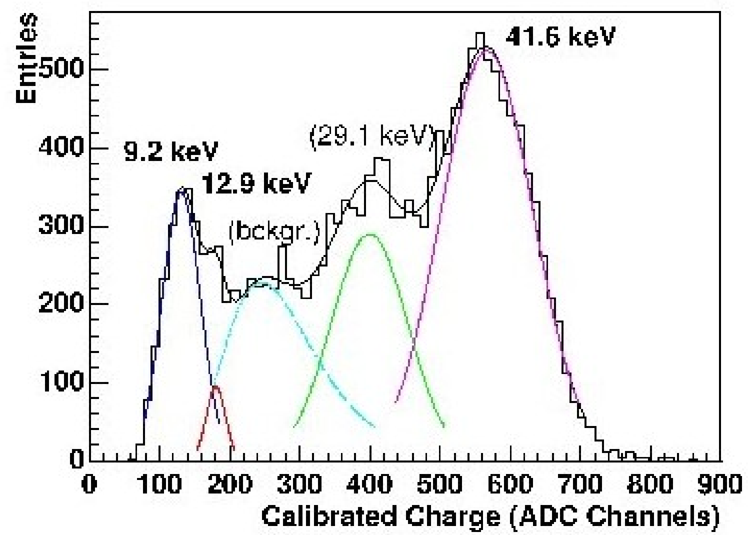


Fig. 9. The measured Krypton spectrum of all pads calibrated with the calibration constants obtained from the Krypton spectra of the single pads. A combined fit using 4 Gaussians for the peaks (solid grey lines) and one Landau distribution for the background (dotted line) was performed. The maximum of the high energy peak was assigned an energy of 41.6 keV and thus the energies of the other peaks were calculated (see values at the various peaks).

5 Conclusions

Summary, further tasks

- Providing the setup with a full set of flash ADC – FQDC, 10 modules ordered, expected in 2 months
- Completion of the upgrade with other tracking detectors: drift chambers with GEM preamplifiers, small straw tubes
- Development and implementation of energy calibration procedures: Fe55 – 5.9 keV <- self triggering DAQ, Kr83 method – radioactive gas 9.3 keV - 41 keV
- Beam test planning : CERN PS, COSY beam test line for energy resolution and PID separation power conclusions
- new generation electronics development (n-XYTER chip, DETNI project, ZTL Julich cooperation
- engineering the connections with straw pins – suitable connector for the realistic straw prototype

Algorithm studies: different estimation of most probable energy loss

Landau distribution has no definite mean. The algorithm used must estimate the most probable energy loss

- ✓ Truncated mean
- ✓ Double truncated mean: truncate at both ends
- ✓ Median
- ✓ Geometric mean

$$\overline{x_g} = \sqrt[n]{\prod_{i=1}^{n} x_i}$$

- ✓ Harmonic mean

$$\overline{x_h} = \frac{n}{\sum_{i=1}^{n} 1/x_i}.$$

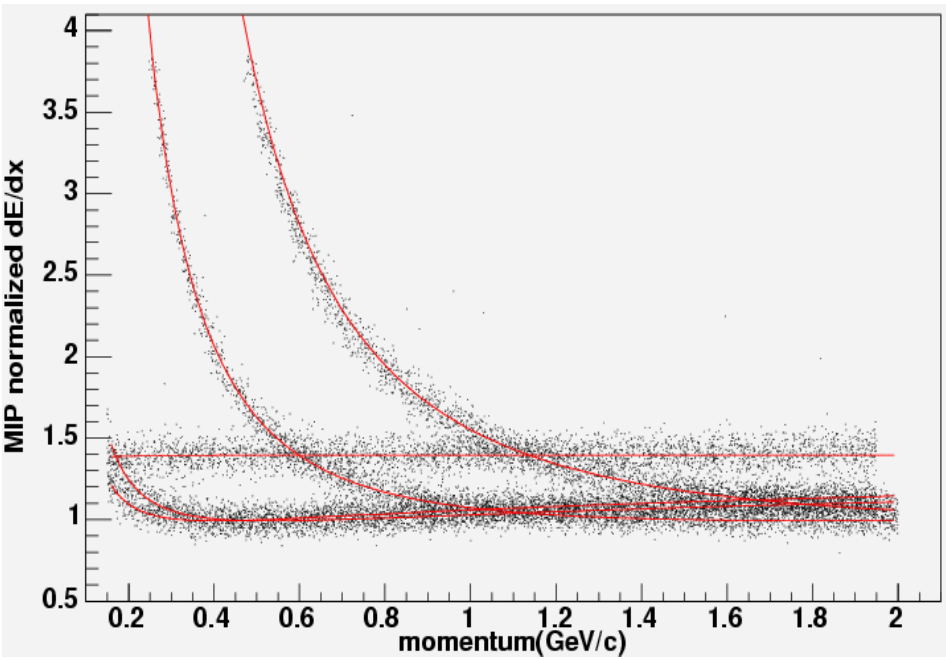
- ✓ Transformation:

$$\langle \mathrm{d}E/\mathrm{d}x \rangle = \left(\sum \frac{1}{\sqrt{\mathrm{d}E/\mathrm{d}x}} \right)^{-1}$$

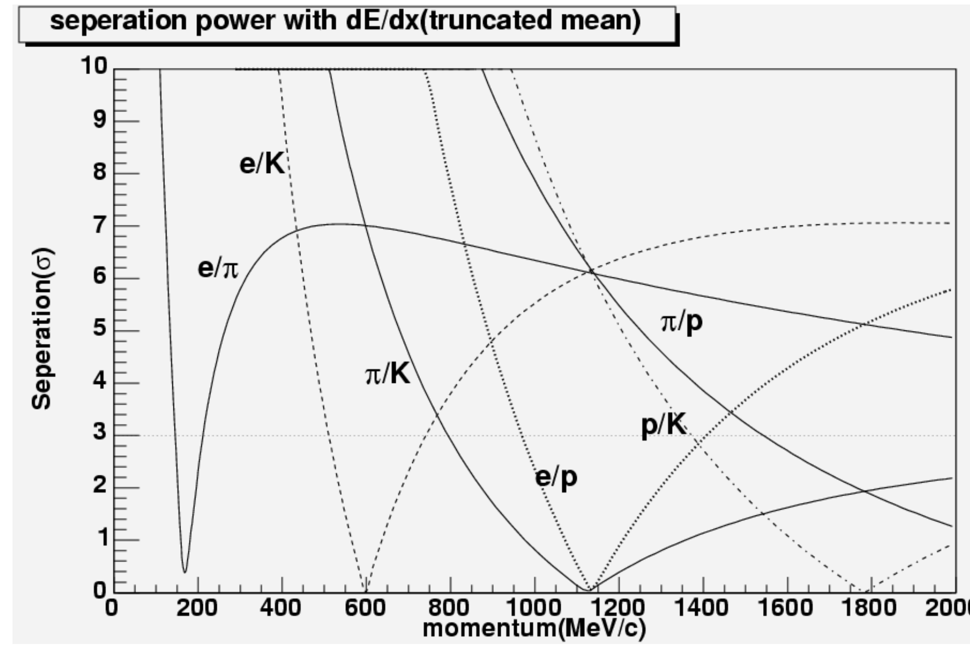
- ✓ Logarithm truncate

idea:these methods give less bias to large values,then the saturated hits have less effect to give better shape and better separation

Particle identification power



dE/dx seperation for 5 particles(MC)



seperation power with dE/dx

- ✓Good particle seperation in a wide range for different particles
- ✓The important π/K seperation(3 σ)can reach nearly 800MeV/c
- ✓Particle identification efficiency is more than 90% with MC samples